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An Estimation of Net Production for Several Macroalgae Species on Vancouver Island, B.C.

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ABSTRACT

Several macroalgae species were sampled over a five month period at three sites on Vancouver Island, British Columbia. Sample biomass (wet weight, dry weight, ash-free weight, and carbon weight) was recorded on a per square metre basis. These measurements were used to estimate the net production or potential contribution of organic carbon of macroalgae species to marine littoral food webs. Comparisons of net production are made between different macroalgae species at each site, between intertidal and subtidal components of each site, and between the different sites.

RÉSUMÉ

Plusieurs espèces de grandes algues ont été échantillonnées au cours d'une période de cinq mois en trois endroits sur l'île de Vancouver, Columbie-Britannique. La biomasse des échantillons (poids humide, poids sec, poids sans cendre et poids de carbone) a été mesurée par mètre carré. Ces mesures ont été utilsées pour évaluer la production nette de carbone organique des grandes algues ou leur contribution possible aux réseaux trophiques du littoral marin. On compare la production nette de différentes espèces de chacun des sites d'échantillonnage; la production nette dans les zones intertidales et subtidales de chacun des sites; et la production nette à chacun des sites.

1.0 Introduction

The contribution of macroalgae in marine foreshore areas to coastal productivity has been studied by Simenstad and Wissmar (1985). They suggest that the most important sources of organic carbon to marine littoral food webs originate primarily from eelgrass, epiphytes, and macroalgae. Several studies have also indicated that in estuaries macroalgae are important producers of organic matter (Correll, 1978; Davis and McIntire, 1981; Pomeroy and Stockner, 1976; Thom, 1981). However, data for the net production of specific macroalgae types found in the marine foreshore is generally lacking. Net production estimates for macroalgae is especially lacking for marine foreshore areas of British Columbia, Canada.

In this paper the net production of several dominant macroalgae species on Vancouver Island, British Columbia are estimated based on biomass measurements.

2.0 Study Area

Macroalgae samples were collected at three different sites on Vancouver Island, British Columbia (see Figure 1). Site 1 (Rocky Point) was located approximately 10 km north of downtown Nanaimo. Site 2 (Millstone River estuary) was located near downtown Nanaimo. Site 3 (Hardy Bay) was located near the B.C. Ferries terminal on the east side of Hardy Bay across from Port Hardy.

Site 1 (Rocky Point) is characterized by a rocky reef intertidal zone. The majority of the intertidal zone is composed of bedrock with some areas of large cobble. Subtidally, the substrate is similar to the intertidal zone to a depth of three metres below zero tide where the substrate changes to sand. At site 1 *Costaria costata*, *Fucus* spp., *Iridaea* spp., *Microcladia* spp., *Neoagardhiella baileyi*, *Porphyra* spp., and *Sargassum muticum* were found attached only to bedrock. *Laminaria* spp. was found attached to large cobble while *Agarum fimbriata* was found attached both to bedrock and to small rocks found in the sand. *Fucus* spp., *Porphyra* spp., and *Sargassum muticum* were found intertidally while all other macroalgae species collected were found subtidally (a diagram showing the local distribution of macroalgae sampled at site 1 - Rocky Point is presented in Figure 2).

Figure 1. Location of Sample Sites.

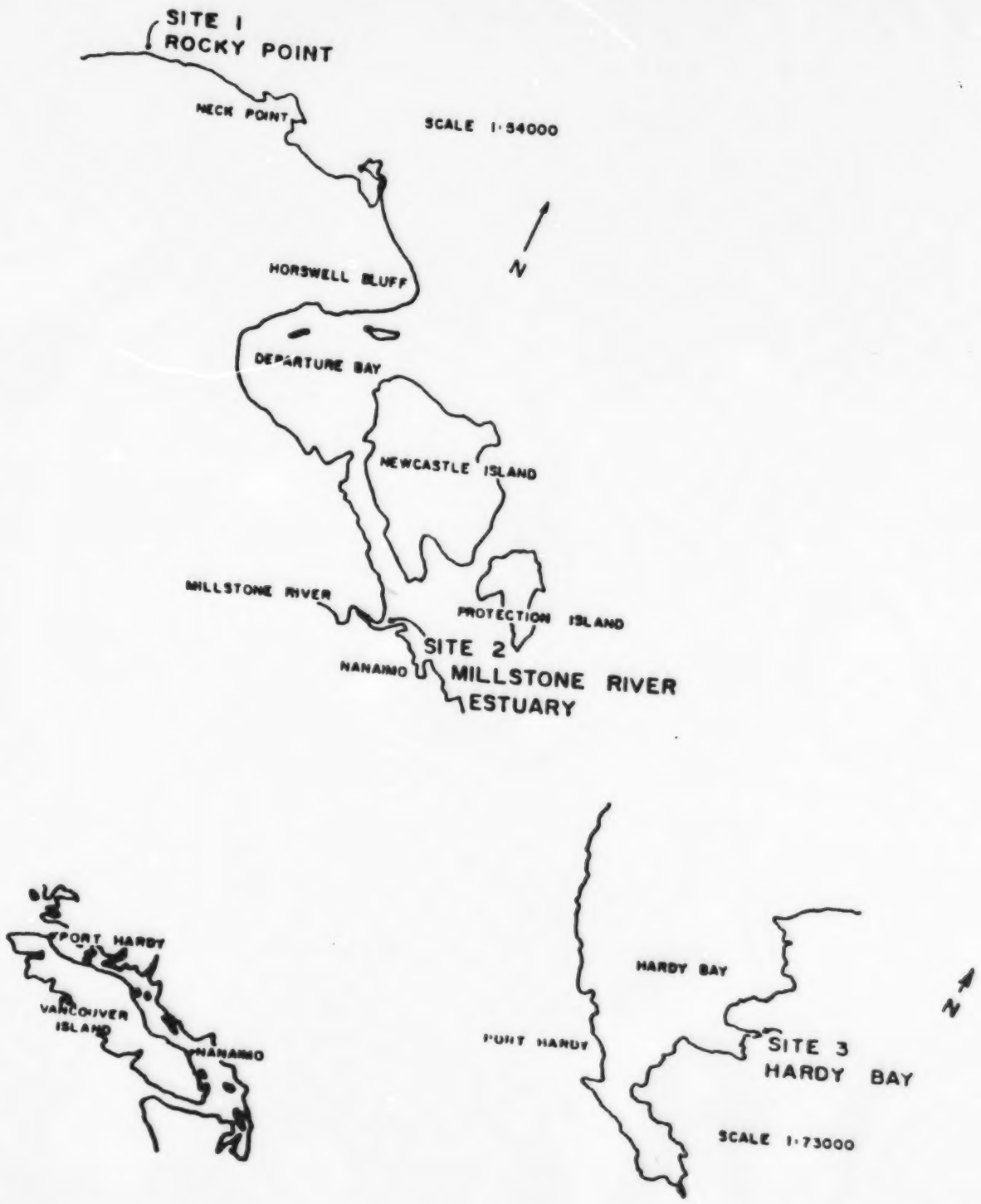
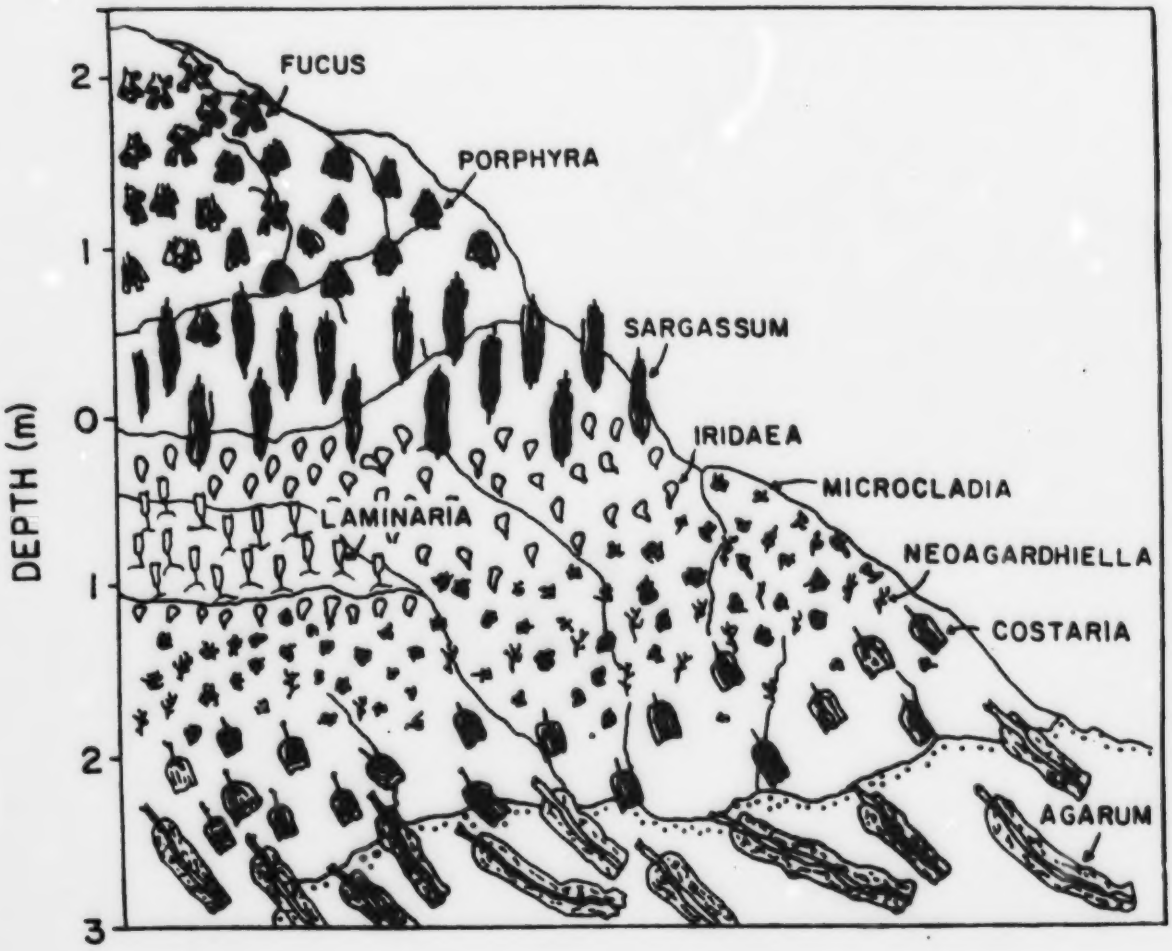


Figure 2. Macroalgae Species Sampled At Site 1 - Rocky Point



Site 2 (Millstone River estuary) is characterized by an intertidal mudflat. Ulva spp. was found attached to gravel and small pieces of clam shell on the mudflat.

Site 3 (Hardy Bay) is characterized by a rocky intertidal zone. The majority of the intertidal zone is composed of bedrock with some areas of angular boulders. Subtidally the substrate is similar to the intertidal zone to a depth of about four metres below zero tide where the substrate changes to a mixture of cobble and sand. At site 3, Microcladia spp., Costaria costata, Desmarestia intermedia, Fucus spp., Iridaea spp., Laminaria saccharina, and Cymathere triplicata were found attached to either bedrock or angular boulders or both. Ulva spp. was found attached to cobble. Fucus spp. was found intertidally while all other macroalgae species were found subtidally (a diagram showing the distribution of macroalgae sampled at site 3 - Hardy Bay is presented in Figure 3).

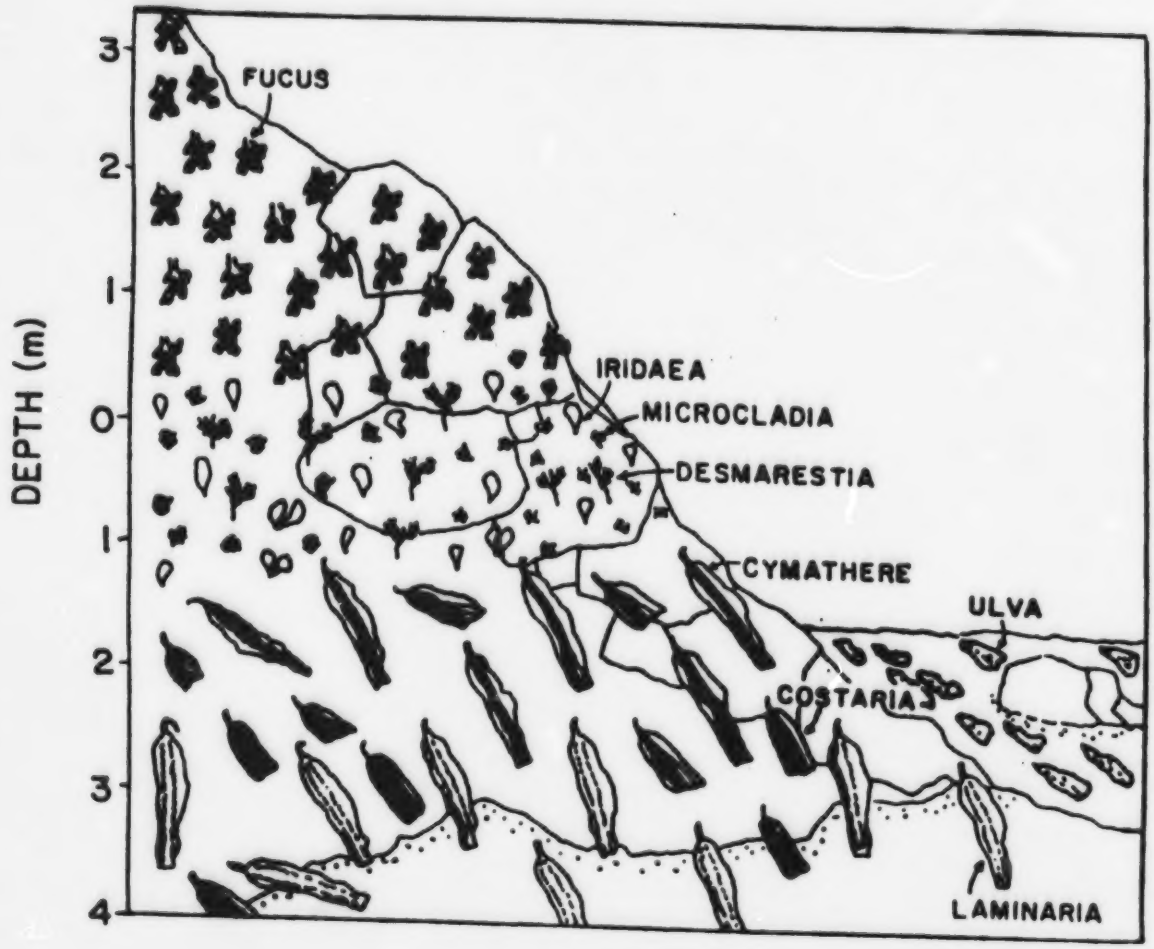
3.0 Method

Macroalgae samples were collected during the months of April 1988 to September 1988 based on the methods of Bellamy et al. (1973). At site 1 (Rocky Point) Agarum fimbriata, Costaria costata, Laminaria spp., Microcladia spp., Neoagardhiella baileyi, and Sargassum muticum were collected at least once a month. Fucus spp., Porphyra spp., and Ulva spp. at site 1 were collected at least every two weeks. At site 2 (Millstone River estuary) Ulva spp. was collected a minimum of every two weeks. At site 3 (Hardy Bay) Microcladia spp., Costaria costata, Desmarestia intermedia, Fucus spp., Iridaea spp., Laminaria saccharina, Cymathere triplicata, and Ulva spp. were collected about once a month.

Most macroalgae samples were collected using S.C.U.B.A. diving equipment, a stainless steel quadrat frame (0.25 m^2 in size), nylon net bags for holding the samples, and a knife for removing the samples from the substrate. The Fucus, Porphyra, Sargassum, and Ulva macroalgae samples at site 1 (Rocky Point) and the Ulva macroalgae samples at site 2 (Millstone River estuary) were collected while exposed at low tide.

Where a specific macroalgae species was fairly uniform, quadrats were placed at random within the zone where maximum coverage occurred. In areas where the occurence of a specific macroalgae species was patchy, quadrats were placed within the zones where maximum coverage occurred on each occasion.

Figure 3. Macroalgae Species Sampled At Site 3 - Hardy Bay



After a quadrat was placed, the macroalgae species to be collected was cropped flush with the substrate. All plant material from the inside of each quadrat was placed in a nylon net bag and brought to the surface and stored in a labelled plastic bag to be transported to the laboratory.

At the laboratory the samples were frozen for a period dependent on the availability of space in the drying oven. As soon as space became available in the drying oven, samples were defrosted for four hours and wet weights were taken (using a dial-a-gram beam balance).

Either the entire wet sample or a subsample was then placed in the drying oven at 100 degrees C for a period of 24 to 48 hours to achieve a constant dry weight (larger samples needed a longer time to dry). After drying each sample was weighed using an electronic balance. The change in wet and dry weight of each macroalgae species over the sampling period was recorded as the change in standing crop per sample for the sampling period.

Either the entire dry sample or a subsample was then placed in a muffle furnace at 500 degrees C for a period of 4.5 hours to achieve a constant ash weight. After each sample was ashed it was weighed using an electronic balance and the ash-free dry weight was estimated.

The ash-free dry weight of each sample was determined by measuring the loss in sample weight after ignition in the muffle furnace. The ash-free dry weight is assumed to equal the weight of organic matter in each sample since during ignition the organic matter in the sample is burned and almost all carbon is oxidized. The non-volatile residue or ash is taken as the inorganic part of the sample while the loss is assumed to be true organic matter (Piper, 1944).

Given the organic matter content of each algae species sampled, a fair estimate of carbon content can be made. Westlake (1963) estimated that most entire plants contain 44 % to 54 % carbon in their organic matter but this range was for all plants types, both terrestrial and aquatic. Pomeroy and Stockner (1972) estimated the carbon content of several types of marine algae to be 45 %.

The maximum change in the carbon content of each macroalgae sample over the sampling period was recorded as the net production of carbon per sample for the sampling period. In this case the term 'net production' refers to the increase in standing crop or the amount of whole plant(s) produced, hence, carbon produced over the sampling period. The estimated net production of carbon, therefore, does not include losses in carbon which may have occurred during the study period. In other words, the net production of carbon estimates do not include the loss of biomass, and hence carbon, due to the loss of whole plants, loss of plant portions due to abrasive action, loss of soluble organic materials, loss of reproductive cells, and material consumed by grazing animals. Thus, any increment in the carbon content of the macroalgae samples will represent:

(Gross production - Respiration) - Losses

Note that the total amount of carbon lost may exceed the total quantity of algal carbon produced during the period of observation.

The biomass data for the report was statistically analysed using the t-test for independent groups with alpha = 0.05 (two-tailed). This test was used because it is a robust test (i.e. the test is relatively insensitive to violations of its underlying mathematical assumptions) (see Pagano, 1981).

4.0 Results

A. Site 1 - Rocky Point

A summary of results for site 1 - Rocky Point is presented in Table 1.

During the sampling of *Agarum fimbriata* at site 1 quadrats were placed to ensure that only one individual plant occurred per quadrat. This occurence of *Agarum* represented 100 % coverage of *Agarum* per quadrat. The observed density of *Agarum* individuals was never greater than one per quadrat (a mean standing crop of 213.7 +/- 92.3 g dry wt/m^2).

Over the sampling period there were no significant changes in *Agarum* with respect to wet weight, dry weight, ash-free dry weight, and grams carbon, per square metre. There was, however, a significant change in the ash-free dry weight:dry weight ratio of *Agarum* over the sampling period.

Table 1. Results Site 1 (Rocky Point)
Grams Per Square Metre

+/- Equals 95% Confidence Interval

		Minimum	+/-	Maximum	+/-	Difference	Mean	+/-	Peak Date
Agarum	Wet Wt	1222.8	378.56	2245.2	827.44	N/S	1598.1	687.1	
100% Maximum	Dry Wt	170.84	109.96	297.04	107.36	N/S	213.73	92.28	-
Coverage	Ash-Free Dry Wt	105.4	69.36	199.24	73.24	N/S	137.52	60.36	-
4 Plants	Carbon	47.44	31.2	89.64	32.96	N/S	61.88	27.17	-
Per M^2	Ash-Free Dry Wt : Dry Wt	0.6136	0.0436	0.7173	0.022	0.1037	0.6655	0.0328	July 26
Costaria	Wet Wt	740	497.08	1490.4	343.64	N/S	1045.9	386.30	
60% Maximum	Dry Wt	53.08	13.32	228.84	35.44	158.04	140.96	24.38	July 26
Coverage	Ash-Free Dry Wt	29.64	7.48	185.68	29.08	125.56	107.66	18.28	July 26
	Carbon	13.36	27.36	83.56	13.08	70.2	48.46	20.22	July 26
	Ash-Free Dry Wt : Dry Wt	0.5515	0.074	0.8113	0.0085	0.2598	0.6814	0.0413	July 26
Fucus	Wet Wt	1660.8	354.7	4261.2	1492.8	2600.4	2961.0	923.75	
95% Maximum	Dry Wt	292.52	65.56	837.76	53.48	545.24	565.14	59.52	June 16
Coverage	Ash-Free Dry Wt	201.8	50.16	773.76	398.32	571.96	487.78	224.24	June 16
	Carbon	90.8	22.6	348.2	179.24	257.4	219.58	100.92	June 16
	Ash-Free Dry Wt : Dry Wt	0.687	0.037	0.9362	0.0113	0.2492	0.8116	0.0242	May 20
Laminaria	Wet Wt	0		2490.4	718.4	1483.6	1245.2	359.20	
95% Maximum	Dry Wt	0		150.64	45.36	150.64	75.32	22.68	April 15
Coverage	Ash-Free Dry Wt	0		82.4	24.44	82.4	41.28	12.22	April 15
	Carbon	0		37.08	11	37.08	18.54	5.50	April 15
	Ash-Free Dry Wt : Dry Wt	0.4452	0.0104	0.5481	0.024	0.1029	0.4967	0.0172	April 15
Microcladia	Wet Wt	1047.6	168.68	1959.6	167.9	912	1503.6	168.29	
80% Maximum	Dry Wt	129.6	26.8	304.04	48.28	174.44	216.82	37.54	June 16
Coverage	Ash-Free Dry Wt	74.56	26.28	148.28	25.28	73.72	111.42	25.78	June 16
	Carbon	33.56	11.84	66.72	11.36	33.16	50.14	11.60	June 16
	Ash-Free Dry Wt : Dry Wt	0.4285	0.0368	0.6054	0.0332	0.1769	0.5178	0.0360	June 16
Neoagardhiella	Wet Wt	78.4	33.2	516.8	201.8	438.4	297.6	117.50	
<5% Maximum	Dry Wt	8.52	2.8	33.72	10.2	25.2	21.12	6.58	June 15
Coverage	Ash-Free Dry Wt	4.92	1.64	15.44	5.72	10.52	10.18	3.68	June 15
	Carbon	2.24	0.76	6.96	12.56	4.72	4.68	6.66	June 15
	Ash-Free Dry Wt : Dry Wt	0.4654	0.0207	0.5806	0..016	0.1332	0.5228	0.0652	July 26
Porphyra	Wet Wt	348.8	133.4	1305.2	135.12	958.4	826.8	134.26	
85% Maximum	Dry Wt	91.08	45.4	304.28	63.36	213.2	197.68	54.38	May 4
Coverage	Ash-Free Dry Wt	59.76	27.16	218.36	41.56	158.6	139.86	34.36	May 4
	Carbon	26.88	12.2	98.28	18.72	71.4	62.98	15.46	May 4
	Ash-Free Dry Wt : Dry Wt	0.642	0.0306	0.7581	0.0372	0.1161	0.7081	0.0339	June 28
Sargassum	Wet Wt	2488.4	543.04	4979.6	3068.44	N/S	3780.7	1801.8	
80% Maximum	Dry Wt	308.72	45.88	653.6	341.68	N/S	518.43	211.52	-
Coverage	Ash-Free Dry Wt	202.12	29.12	431.16	242.08	N/S	339.87	144.96	-
	Carbon	90.96	13.12	194.04	108.92	N/S	152.99	65.23	-
	Ash-Free Dry Wt : Dry Wt	0.6603	0.0058	0.6734	0.033	N/S	0.6666	0.0185	-

Results Site 2 (Millstone River Estuary)

Ulva	Wet Wt	0		2377.6	899.24	2377.6	1188.8	449.62	
95% Maximum	Dry Wt	0		689.8	287.28	689.8	344.98	143.64	Jun 17
Coverage	Ash-Free Dry Wt	0		133.88	40.52	133.88	66.94	20.26	Jun 17
	Carbon	0		60.24	18.24	60.24	30.12	9.12	Jun 17
	Ash-Free Dry Wt : Dry Wt	0.2021	0.048	0.3888	0.1587	N/S	0.2955	0.1034	May 5

Costaria costata at site 1 was sampled by placing quadrats in areas with maximum coverage. The maximum coverage did not change over the sampling period and remained at about 60 % (a mean standing crop of 141.0 +/- 24.4 g dry wt/m^2).

There were no significant changes in the wet weight per square metre of Costaria during the sampling period. There were, however, significant changes in dry weight, ash-free dry weight, and grams carbon, per square metre, as well as, in the ash-free dry weight:dry weight ratio of Costaria over the sampling period. Maximum weight measurements per square metre occurred during the July 26 sampling. Increases in weight measurements to July 26 were likely due to an observed increase in plant size. Decreases in weight measurements after July 26 corresponded with the observed loss of Costaria biomass due to attrition and/or grazing.

With respect to Fucus spp., Laminaria spp., Microcladia spp., Neoagardhiella baileyi, and Porphyra spp., there were significant changes in wet weight, dry weight, ash-free dry weight and grams carbon, per square metre, as well as, in the ash-free dry weight:dry weight ratio over the sampling period.

For Fucus spp. at site 1 maximum coverage approximated 95 % over the sampling period (a mean standing crop of 565.1 +/- 59.5 g dry wt/m^2). Maximum weight measurements per square metre for Fucus occurred during the June 16 sampling.

For Laminaria spp. at site 1 the percent coverage changed from 95 % (a standing crop of 75.3 +/- 22.7 g dry wt/m^2) to 0 % coverage (a standing crop of 0 g dry wt/m^2) over the sampling period. Maximum weight measurements per square metre for Laminaria occurred during the first sampling (April 15) although the maximum likely occurred before this date. Decreases in weight measurements after April 15 corresponded with the observed loss of Laminaria biomass due to attrition and/or grazing (hence, the decrease in % coverage).

Microcladia spp. at site 1 was sampled where the percent coverage remained near 80 % over the sampling period (a mean standing crop of 216.8 +/- 37.5 g dry wt/m^2). Maximum weight measurements per square metre for Microcladia occurred during the June 16 sampling.

Neoagardhiella at site 1 was sampled where the plants represented < 5 % coverage (the maximum coverage observed throughout the sampling period). A mean standing crop of 21.1 +/- 6.5 g dry wt/m^2 was recorded and maximum weight measurements per square metre for Neoagardhiella occurred during the June 15 sampling. Increases in weight measurements to June 15 corresponded to an observed increase in plant size. Decreases in weight measurements after June 15 corresponded with an observed change in Neoagardhiella from a red to a green/yellow colour. This decrease in weight measurement may be due to the possibility that Neoagardhiella is an annual species which dies back in the late summer.

Porphyra at site 1 was sampled where the plants represented a maximum percent coverage of 85 % (a standing crop of 304.3 +/- 91.1 g dry wt/m^2). Over the sampling period this maximum % coverage was reduced to 20 % (a standing crop of 91.1 g dry wt/m^2). Maximum weight measurements per square metre for Porphyra occurred during the May 4 sampling. Decreases in weight measurements after May 4 corresponded to not only an observed decrease in the maximum percent coverage but also an observed change in Porphyra from steel purple to a brown/green colour. This decrease in weight measurement and maximum percent coverage may be due to the possibility that Porphyra is an annual species which dies back in the summer.

Sargassum muticum coverage at site 1 remained nearly constant at 80 % over the sampling period (a mean standing crop of 510.4 +/- 211.5 g dry wt/m^2). There were no significant changes in Sargassum over the sampling period with respect to wet weight, dry weight, ash-free dry weight, grams carbon, per square metre and ash-free dry weight:dry weight ratio. There were, however, observed changes in Sargassum after the June 16 sampling. These changes consisted of a reduction in the number of long strands of plant material attached to individual plant holdfasts. These holdfasts showed evidence of the growth of small blades of plant material replacing the loss of the long strands.

B. Site 2 - Millstone River Estuary

A summary of results for site 2 - Millstone River Estuary is presented in Table 1.

Ulva spp.

Ulva spp. at site 2 was sampled where coverage was the maximum of 90 % (a standing crop of 689.8 +/- 287.3 g dry wt/m^2). Over the sampling period this maximum coverage was reduced to 0 % (a standing crop of 0 g dry wt/m^2). During the sampling period there were significant changes in wet weight, dry weight, ash-free dry weight and grams carbon, per square metre. Maximum weight measurements per square metre occurred during the June 17 sampling. Decreases in weight measurements after June 17 corresponded to the observed loss of plant biomass (hence, the decrease in % coverage). There was also a significant change in the ash-free dry weight:dry weight ratio over the sampling period.

C. Site 3 - Hardy Bay

A summary of results for site 3 - Hardy Bay is presented in Table 2.

During the sampling period there were significant changes in Costaria costata, Desmarestia intermedia, Iridaea spp., and Microcladia spp. based on wet weight, dry weight, ash-free dry weight, grams carbon, per square metre and ash-free dry weight:dry weight ratio.

Costaria at site 3 was sampled where 60 % was the maximum coverage (a mean standing crop of 131.1 +/- 50.9 g dry wt/m^2). This maximum coverage did not change over the sampling period. Maximum weight measurements per square metre for Costaria occurred during the August 11 sampling.

During the sampling of Desmarestia at site 3 quadrats were placed to ensure that only one individual plant occurred per quadrat. This represented about 20 % coverage by Desmarestia per quadrat. The observed density of Desmarestia individuals was never greater than one per quadrat (a mean standing crop of 61.5 g dry wt/m^2). Maximum weight measurements per square metre for Desmarestia occurred during the April 27 sampling.

Iridaea spp. at site 3 was sampled where maximum coverage remained at about 80 % over the sampling period (a mean standing crop of 86.0 +/- 22.3 g dry wt/m^2). Maximum weight measurements per square metre for Iridaea occurred during the June 11 sampling.

For Microcladia spp. at site 3 the plants' maximum coverage remained at a constant 80 % over the sampling period (a mean standing crop of 225.6 +/- 76.1 g dry wt/m^2). Maximum weight measurements per square metre for Microcladia occurred during the July 14 sampling.

Cymathere triplicata, Fucus spp., and Laminaria saccharina showed no significant changes in wet weight, dry weight, ash-free dry weight, and grams carbon, per square metre. There were, however, significant changes in the ash-free dry weight: dry weight ratio over the sampling period for these three macroalgae types.

Cymathere at site 3 was sampled where coverage was the maximum of 50 %, which remained nearly constant over the sampling period (a mean standing crop of 96.8 +/- 43.4 g dry wt/m^2).

Fucus at site 3 was sampled where a maximum coverage of 95 % remained fairly constant over the sampling period (a mean standing crop of 907.8 +/- 264.3 g dry wt/m^2).

For Laminaria at site 3 the plants' maximum percent coverage remained at a constant 95 % over the sampling period (a mean standing crop of 165.2 +/- 77.2 g dry wt/m^2).

Table 2. Results Site 3 (Port Hardy)
Grams Per Square Metre

+/- Equals 95% Confidence Interval

		Minimum	+/-	Maximum	+/-	Difference	Mean	+/-	Peak Date
Costaria	Wet Wt	443.6	403.88	1564.3	329.8	1121.2	1004.2	369.84	
60% Maximum	Dry Wt	41.48	50.32	220.3	51.52	179.32	131.14	50.92	August 11
Coverage	Ash-Free Dry Wt	25.2	32.52	145.72	38	120.52	85.46	35.26	August 11
	Carbon	11.32	14.64	65.56	17.12	54.24	38.44	15.88	August 11
	Ash-Free Dry Wt : Dry Wt	0.5708	0.032	0.6572	0.0464	0.0864	0.6140	0.0392	August 11
Cystathere	Wet Wt	692.4	142.24	1632.4	966.4	N/S	1162.4	554.32	
60% Maximum	Dry Wt	73.2	15.04	120.4	71.68	N/S	96.8	43.36	-
Coverage	Ash-Free Dry Wt	45	18.04	63.64	40.96	N/S	54.32	29.5	-
	Carbon	20.24	8.12	28.64	18.44	N/S	24.44	13.28	-
	Ash-Free Dry Wt : Dry Wt	0.5177	0.0627	0.6482	0.0431	0.1305	0.5830	0.0529	July 14
Desmarestia	Wet Wt	0		1030.4		1030.4	515.2		
20% Maximum	Dry Wt	0		123.04		123.04	61.52		April 27
Coverage	Ash-Free Dry Wt	0		88.08		88.08	44.04		April 27
	Carbon	0		30.92		30.92	15.46		April 27
	Ash-Free Dry Wt : Dry Wt	0.6354		0.717		0.0816	0.6762		April 27
Fucus	Wet Wt	3750.8	734.44	6052.8	2702.6	N/S	4901.8	1718.52	
95% Maximum	Dry Wt	850.8	259.4	964.8	269.24	N/S	907.8	264.32	-
Coverage	Ash-Free Dry Wt	574.92	167.08	761.44	234.48	N/S	668.18	200.78	-
	Carbon	258.72	75.2	342.64	105.52	N/S	300.68	90.36	-
	Ash-Free Dry Wt : Dry Wt	0.642	0.0263	0.7856	0.0336	0.1436	0.7138	0.0300	August 11
Iridaea	Wet Wt	339.2	92.52	900	230.4	560.8	619.6	161.46	
80% Maximum	Dry Wt	43.56	15.64	128.36	28.88	84.8	85.96	22.26	June 1
Coverage	Ash-Free Dry Wt	32.24	10.68	83.84	21.32	51.6	58.04	16	June 1
	Carbon	14.52	4.8	37.72	9.6	23.2	26.12	7.2	June 1
	Ash-Free Dry Wt : Dry Wt	0.5967	0.0276	0.7454	0.0374	0.1487	0.6711	0.0325	August 11
Laminaria	Wet Wt	1051.6	521.72	2417.2	2026.96	N/S	1749.4	1274.34	
95% Maximum	Dry Wt	100	60.96	230.4	93.36	N/S	165.2	77.16	
Coverage	Ash-Free Dry Wt	49.24	36.96	143.2	61.92	N/S	96.22	43.44	
	Carbon	22.16	16.64	64.44	27.84	N/S	86.6	22.24	
	Ash-Free Dry Wt : Dry Wt	0.3006	0.1694	0.6179	0.0325	0.3173	0.4593	0.1010	July 14
Microcladia	Wet Wt	549.2	156.32	2213.2	808.88	1664	1381.2	482.60	
80% Maximum	Dry Wt	79.4	14.96	371.88	137.32	292.48	225.64	76.14	July 14
Coverage	Ash-Free Dry Wt	45.64	5.72	209.68	72.52	164.04	127.66	39.12	July 14
	Carbon	20.56	2.56	94.36	32.64	73.8	57.46	17.6	July 14
	Ash-Free Dry Wt : Dry Wt	0.4061	0.0314	0.5787	0.039	0.1037	0.5324	0.0352	August 11
Ulva	Wet Wt	854	194.04	1236.8	159.44	382.8	1045.4	176.74	
85% Maximum	Dry Wt	82.64	24.64	103.76	20.72	N/S	93.2	22.68	-
Coverage	Ash-Free Dry Wt	46.88	11.2	63.56	13.08	N/S	55.22	12.14	-
	Carbon	21.08	5.04	28.6	5.88	N/S	24.84	5.46	-
	Ash-Free Dry Wt : Dry Wt	0.5582	0.1132	0.6231	0.0721	0.1161	0.5907	0.0927	June 1

During the sampling period there were significant changes in the wet weight per square metre of Ulva spp. as well as in the ash-free dry weight:dry weight ratio. There were, however, no significant changes in the dry weight, ash-free dry weight, and grams carbon per square metre. Ulva at site 3 was sampled by placing quadrats in areas where the plants represented maximum coverage. The maximum coverage did not change over the sampling period and remained at about 85 % (a mean standing crop of 93.2 +/- 22.7 g dry wt/m^2).

5.0 Discussion

A. General Discussion

Following are estimates of net production of the macroalgae species sampled during the study. A summary of the net production estimates for each macroalgae species is presented in Table 3.

In all cases net production has been estimated by calculating seasonal changes in either dry weight, ash-free dry weight, or grams carbon. These estimation methods are listed in order of increasing accuracy. Wet weights have not been used as an estimate of net production due to a wide variation in results. This variation resulted from difficulties in standardizing the collection of wet samples, especially for those samples collected at low tide which varied in wet weight depending on the amount of time they had been exposed.

Note that in some cases the ash-free dry weight and carbon estimates may more accurately reflect the net production per year of each algal species than the use of measured dry weights alone. If there are significant changes in the ash-free dry weight:dry weight ratio over the sampling period for an algal species dry weights will not accurately reflect carbon content. Increases observed in the ash-free dry weight : dry weight ratio over the sampling period may be due to the storage of carbon in the summer by algae to provide energy for late winter growth as Luning et al. (1973) and Boney (1966) have suggested.

Also note that the given net production estimates for each algal species may be underestimated for two reasons.

First, the estimates have not considered biomass measurement factors such as spore release, exudation, loss of dissolved organic material, and loss of plant material due to wave erosion and/or consumption by grazing animals. Westlake (1963) suggests that non-respiratory losses of carbon may be large. Khailov and Burlakova (1969) estimate that the approximate quantities of total dissolved organic matter released per year may be about 39% of gross production in brown algae, about 38% in red algae and about 23% in green algae. Sieburth (1969) estimates that the extracellular release of soluble organic material from Fucus vesiculosus may be in the order of 30% of gross production and from Laminaria spp. may be near 35% of gross production. Mann (1972) suggests that Laminaria may lose up to five times of its biomass to wave erosion and/or to grazing animals over the course of a year.

The second possible reason for underestimation of net biomass was that budgetary constraint limited macroalgae sampling to a five month period. It is possible that the growth of some of the species sampled was highly seasonal. In other words, some of the species sampled either decreased or increased in standing crop (biomass) per square metre during the period when sampling did not occur. Therefore, the results from the five month study were not expanded to annual values and, consequently, the macroalgae biomass per square metre and net production estimates given in this study could be underestimated.

Also note that the given net production estimates for each algal species may be overestimated. In this study net biomass was estimated from sample quadrats that were placed in areas of maximum coverage. The net production estimates may be overestimated since the average coverage of each algal species in a particular area, which would be lower than the maximum coverage observed, would be more representative of net production.

There is also one uncertainty that may lead to both an overestimation or underestimation of net production. For some species, average values for frond elongation and percentage of gross production released in dissolved form over a one year period were cited and applied. It can not be assumed that at the study locations these values are similar to those values found in the literature.

Regardless of the possible errors in the estimation of algal net production by using the biomass measurement method used in this study, Pomeroy (1961) suggests that 'no single method (of estimating the net production of macroalgae) has been found to be best in all situations and in a given case the investigator must decide which method is most suitable for his intended purpose, modify it as needed, and then critically review its accuracy as it is actually used by him'. In this report the use of the biomass measurement method to estimate net algal production was chosen because of its ease and the apparatus required.

Although there are several uncertainties in the net production estimates given in this report the estimates represent the best figures currently available for the species sampled at the study locations.

8. Site 1 - Rocky Point

Agarum fimbriata

The results indicate that the observed seasonal changes in net biomass of Agarum are not significant. These results, however, may be deceiving because the worn condition of the blades of the sampled plants indicated that biomass may have been lost by erosion or by grazing during the sampling period. Mann (1972) suggests that blades of Agarum are 'moving belts' of tissue, growing at the junction of the blade with the stipe and eroding at the blade end. He also found that Agarum blades renewed their length an average of once during the year. The observed amount of change in biomass over the sampling period is, therefore, much less than the actual amount of biomass production.

Using the above assumption the actual rate of carbon production for Agarum at Rocky Point can be estimated to be 125 g carbon/m^2/yr (at the maximum observed coverage of 100%). This estimate may still be low because factors such as spore release, exudation, and loss of dissolved organic material have not been included. There is no data for the percentages of gross production which may be due to these other factors for Agarum. The best data available is from Khailov and Burlakova (1969) who estimate brown algaes to release about 39% of their gross production in dissolved form. Assuming that Agarum releases 39 % of its gross production in dissolved form the actual rate of carbon production could be as high as 175 g carbon/m^2/year (assuming the maximum coverage occurring over the year is 100 %). The average coverage of Agarum in the subtidal zone is estimated to be 15%. At this average coverage the actual rate of carbon production is estimated to be 25 g carbon/m^2/year.

Costaria costata

The results suggest that there is a significant net production per year of Costaria based on dry weight / m^2 / year, ash-free dry weight / m^2 / year, and carbon / m^2 / year. The wet weight results do not reflect a net production per year of Costaria. The net production per year of Costaria may be underestimated as the worn condition of plant blades during the June 15 sampling and after indicated that biomass had been lost by erosion or grazing during the sampling period.

There is very little data available concerning the growth rate of Costaria. Observations of sampled plants indicate that as much as 80 % of whole individuals may have eroded away or been eaten. Using this estimate, the rate of production for Costaria at Rocky Point may be in the neighbourhood of 125 g carbon/m^2/year. Assuming, from Khailov and Burlakova's (1969) estimates, that Costaria (a brown algae) releases 39 % of gross production in dissolved form the actual rate of carbon production could be as high as 170 g carbon/m^2/year (assuming also that the maximum coverage occurring over the year is 60 %). At an average coverage by Costaria in the subtidal zone of 5% the actual rate of carbon production is estimated to be 14 g carbon/m^2/year. In places where Costaria is observed to cover 100 % of the substrate, carbon production could theoretically approach 270 g carbon/m^2/year.

Fucus spp.

As the results indicate, there is a significant net production per year of Fucus in terms of wet weight / m^2 / year, dry weight / m^2 / year, ash-free dry weight / m^2 / year, and carbon / m^2 / year. The biomass lost due to attrition and/or grazing over the sampling period cannot be determined. The amount of dissolved organic material released over the year, however, can be estimated. As mentioned previously, Sieburth's (1969) estimates that Fucus releases 30 % of its gross production in dissolved form. Using Sieburth's data the actual rate of carbon production for Fucus could be as high as 335 g carbon/m^2/year assuming 95 % coverage is observed. If the maximum coverage observed was 100 %, carbon production could approach 350 g carbon/m^2/year. In the intertidal zone the average coverage of Fucus is approximately 30% with an estimated carbon production of 105 g carbon/m^2/year.

Laminaria spp.

The *Laminaria* sampled at site 1 was represented by juvenile plants, making exact identification of species almost impossible. The results suggest that there is a significant net production of *Laminaria* per year in terms of wet weight / m^2 / year, dry weight / m^2 / year, ash-free dry weight / m^2 / year, and carbon / m^2 / year.

The worn condition of individual plants during sampling and the eventual disappearance of *Laminaria* provides evidence that plant biomass has been lost by erosion by waves and/or by grazing. Mann (1972) suggests that *Laminaria* spp. may renew their length an average of 2.5 times a year. The apparent rate of change of biomass is, therefore, likely to be less than the true rate of production. Since the *Laminaria* sampled at Rocky Point existed for slightly less than half a year, the plants theoretically could have renewed their length once. Using the above assumption, the actual rate of carbon production for *Laminaria* at Rocky Point may be estimated to be 75 g carbon/m^2/year. This actual rate of production may still be underestimated because factors such as spore release, exudation, and the loss of dissolved organic material have not been included. Laminarians have been estimated to release 35 % (Sieburth and Jensen, 1969) to 39 % (Khailov and Burlakova, 1969) of their gross production in the dissolved form. Assuming that *Laminaria* releases 35 % of its gross production in the dissolved form the actual rate of carbon production could be as high as 100 g carbon/m^2/year (assuming that 95 % is the maximum coverage obtained over the year) or 105 g carbon/m^2/year if 100 % coverage is assumed. In the subtidal zone at Rocky Point *Laminaria* coverage averages 10% providing a net carbon production of 11 g carbon/m^2/year.

Also note that the peak in instantaneous standing crop / m^2 occurs in the spring whereas for almost all other species the peak occurs in late summer. The decrease in standing crop of Laminaria during the sampling period is marked by the total disappearance of *Laminaria* by the middle of June. Perhaps *Laminaria*'s disappearance at Rocky Point was related to its inability to grow at a faster rate than it eroded or was eaten by predators. This observation is consistent with that of Kain (1979) who suggested that the typical growth rate of *Laminaria* spp. is characterized by rapid growth from late winter to late spring and minimal growth in summer, independent of environmental conditions.

Microcladia spp.

The results show significant net production per year of Microcladia based on wet weight / m^2 / year, dry weight / m^2 / year, ash-free dry weight / m^2 / year, and carbon / m^2 / year. The biomass of Microcladia lost due to attrition and/or grazing over the sampling period cannot be determined. With respect to the release of dissolved organic matter, Khailov and Burlakova (1969) estimate that Microcladia (a red algae) releases 38% of gross production in dissolved form. If Khailov and Burlakova's estimates are correct the actual rate of carbon production could be as high as 8 g carbon/m^2/year (assuming an average subtidal coverage of 15%) or as high as 45 g carbon/m^2/year (assuming that 80 % is the maximum coverage obtained during the year). If 100 % coverage was the maximum obtained, this carbon production estimate would increase to 54 g carbon/m^2/year.

Neoagardhiella baileyi

The results indicate significant net production per year of Neoagardhiella based on wet weight / m^2 / year, dry weight / m^2 / year, ash-free dry weight / m^2 / year, and carbon / m^2 / year. The biomass of Neoagardhiella lost due to attrition and/or grazing over the sampling period cannot be determined. The amount of dissolved organic matter released during the year, however, can be estimated. Khailov and Burlakova (1969) estimate that Neoagardhiella (a red algae) releases 38% of gross production in dissolved form. Using Khailov and Burlakova's data the actual rate of carbon production could be as high as 1.0 g carbon/m^2/year (assuming an average subtidal coverage of 1%) or 6.5 g carbon/m^2/year (assuming that maximum % coverage does not exceed 5 %). If maximum coverage obtained were 100 %, carbon production could approach 124 g carbon/m^2/year.

Porphyra spp.

The results suggest that there is a significant net production per year of Porphyra based on wet weight, dry weight, ash-free dry weight, and carbon weight, per square metre per year. The biomass of Porphyra lost due to attrition and/or grazing over the sampling period cannot be determined. The amount of dissolved organic matter released by Porphyra over the year, however, can be estimated.

Assuming, from Khailov and Burlakova's (1969) estimates, that Porphyra (a brown algae) releases 38% of gross production in dissolved form the actual rate of carbon production could be as high as 98 g carbon/m^2/year (also assuming that the maximum % coverage over the sampling period does not exceed 85 %). If the maximum coverage obtained were 100 %, carbon production could be as high as 113 g carbon/m^2/year. With an average coverage of 30% in the intertidal zone net carbon production is estimated to be 34 g carbon/m^2/year.

Sargassum spp.

As no significant change in standing crop per year of Sargassum occurred net production is estimated to be zero. The result may be deceiving, however, because of factors that are not taken into account when using biomass measurements to estimate net production (see general discussion). Visual observations of individual plants indicate a loss of biomass has occurred over the sampling period (see results section). Had sampling continued past the last sampling date or over a one year period the estimated net production per year of Sargassum may have been significant.

C. Site 2 - Millstone River Estuary

Ulva spp.

There is a significant net production per year of Ulva based on wet weight, dry weight, ash-free dry weight, and grams carbon, per square metre according to the observed results. The amount of biomass lost over the year cannot be determined but the amount of dissolved organic material released over the year can be estimated. Khailov and Burlakova (1969) suggest that Ulva (a green algae) releases 23 % of gross production in dissolved form, thus, the actual rate of carbon production could be as high as 21 g carbon/m^2/year at an average coverage of 25% in the intertidal zone or as high as 74 g carbon/m^2/year if maximum coverage remains at 85 %. If maximum coverage approaches 100 % carbon production could approach 85 g carbon/m^2/year.

D. Site 3 - Hardy Bay

Costaria costata

There is a significant net production per year of Costaria based on wet weight, dry weight, ash-free dry weight, and grams carbon, per square metre.

Unfortunately, there is very little data available concerning the growth rate of Costaria. Observations of sampled plants indicate that as much as 20 % of whole individuals may have eroded away or been eaten. Using this estimate, the rate of production for Costaria at Hardy Bay may be in the neighbourhood of 65 g carbon/m^2/year. Assuming, from Khailov and Burlakova's (1969) estimates, that Costaria (a brown algae) releases 39% of gross production in dissolved form the actual rate of carbon production could be as high as 13 g carbon/m^2/year (at an average coverage of 10% in the subtidal zone) or 90 g carbon/m^2/year (if maximum coverage remains at 60 %). If maximum coverage increased to 100 %, carbon production could approach 126 g carbon/m^2/year.

Cymathere triplicata

As the results show, the observed changes in standing crop per year of Cymathere are not significant. These results, however, may underestimate production because of factors that are not taken into account when using biomass measurements to estimate net production (see general discussion). One such factor is the loss of biomass by erosion or by grazing during the sampling period which was evident from the worn condition of the tips of the sampled Cymathere plants.

Desmarestia intermedia

The results show that there is a significant net production per year of Desmartesia based on wet weight / m^2 / year, dry weight / m^2 / year, ash-free dry weight / m^2 / year, and carbon / m^2 / year while the amount of biomass lost over the year cannot be determined. Khailov and Burlakova (1969) estimate that Desmarestia (a brown algae) releases 39% of its gross production in dissolved form. Using their data the actual rate of carbon production could be as high as 2 g carbon/m^2/year if the average coverage in the subtidal zone zone remains at 1% or 43 g carbon/m^2/year if the maximum coverage observed is 20 %. If the maximum coverage observed is 100 %, carbon production could approach 215 g carbon/m^2/year.

Fucus spp.

Observed changes in the standing crop per year of Fucus are not significant. The results, however, may be deceiving because of factors not taken into account when estimating net production using biomass measurements (see general discussion).

Iridaea spp.

The results indicate a significant net production per year of Iridaea in terms of wet weight / m^2 / year, dry weight / m^2 / year, ash-free dry weight / m^2 / year, and grams carbon / m^2 / year. These results, however, may be underestimated due to the factors noted in the general discussion. Khailov and Burlakova (1969) estimate that Iridaea (a red algae) releases 38% of its gross production in dissolved form. Using this data the actual rate of carbon production could be as high as 2 g carbon/m^2/year if the average coverage in the subtidal zone remains at 5% or 32 g carbon/m^2/year if the maximum coverage observed is 80 %. If the maximum coverage observed is 100 %, carbon production could approach 38 g carbon/m^2/year.

Laminaria saccharina

The results indicate no significant change in standing crop per year of Laminaria saccharina. The worn condition of the tips of individual plants during sampling suggests that plant biomass was lost by wave erosion and/or by grazing. Mann (1972) suggests that Laminaria may renew their length up to five times a year. The apparent rate of change of biomass is, therefore, likely to be less than the true rate of production. If the Laminaria plants at Hardy Bay renew their length five times a year the actual rate of carbon production for Laminaria may be estimated to be 430 g carbon/m^2/year. This rate may still be low because factors such as spore release, exudation, and the loss of dissolved organic material have not been included. Laminarians have been estimated to release 35 % (Sieburth and Jensen, 1969) to 39 % of their gross production in the dissolved form (Khailov and Burlakova, 1969). Assuming that Laminaria releases 35 % of its gross production in this manner the actual rate of carbon production could be as high as 60 g carbon/m^2/year if the avarge coverage in the subtidal zone remains at 10% or 580 g carbon/m^2/year (assuming that 95% is the maximum coverage obtained over the year) or 600 g carbon/m^2/year if 100% coverage is assumed.

Microcladia spp.

There was significant net production per year of Microcladia based on wet weight/m^2/year, dry weight/m^2/year, ash-free dry weight/m^2/year, and carbon/m^2/year. Net production may be underestimated, however, because of factors not taken into account when estimating net production using biomass estimates (see general discussion). The amount of biomass lost over the sampling period, for instance, cannot be determined. However, Khailov and Burlakova (1969) estimate that Microcladia (a red algae) releases 38% of gross production in dissolved form. Using their estimatation, the actual rate of carbon production could be as high as 6 g carbon/m^2/year (at an average coverage of 5% in the subtidal zone) or 102 g carbon/m^2/year (assuming that 80% is the maximum coverage obtained during the year). If 100% coverage was the maximum obtained the carbon production estimate would increase to 122 g carbon/m^2/year.

Ulva spp.

There were no significant changes in standing crop per year of Ulva. There was a significant change in wet weight/m^2 for Ulva during the sampling period. This change, however, is most likely due to the unstandardized collection of wet samples (see general discussion). The insignificant net production results may be deceiving as several factors are not taken into account when using biomass measurements to estimate net production. These factors, if taken into consideration, could cause the net production per year of Ulva at Hardy Bay to become significant.

Table 3. Summary of Net Production Estimates.
Net Production Units = Grams Carbon/m^2/Year

1. Rocky Point

Intertidal	Net Production 100 % Coverage	Average % Coverage In Intertidal Zone	Net Production At Average % Coverage In Intertidal Zone	Maximum Observed % Coverage	Mean Dry Wt (g/m^2) At Max Observed % Coverage	Net Production At Max Observed % Coverage	P/B (Net Production/Mean Dry Wt)
Fucus	350	30	105	95	565	335	0.6
Porphyra	113	30	34	85	198	98	0.5
Sargassum	?	15	?	80	510	?	?
Other	154 (a)	25	39				
			178				

Subtidal	Net Production 100 % Coverage	Average % Coverage In Subtidal Zone	Net Production At Average % Coverage In Subtidal Zone	Maximum Observed % Coverage	Mean Dry Wt (g/m^2) At Max Observed % Coverage	Net Production At Max Observed % Coverage	P/B (Net Production/Mean Dry Wt)
Agarum	175	15	25	100	214	175	0.8
Costaria	270	5	14	60	141	170	1.2
Laminaria	105	10	11	95	75	100	1.3
Microcladia	54	15	8	80	217	45	0.2
Neoagardhiella	124	1	1	5	21	7	0.3
Other	89 (b)	54	47				
			106				

2. Millstone River Estuary

Intertidal	Net Production 100 % Coverage	Average % Coverage In Intertidal Zone	Net Production At Average % Coverage In Intertidal Zone	Maximum Observed % Coverage	Mean Dry Wt (g/m^2) At Max Observed % Coverage	Net Production At Max Observed % Coverage	P/B (Net Production/Mean Dry Wt)
Ulva	85	25	21	90	345	74	0.2
Other	85 (c)	75	64				
			85				

3. Hardy Bay

Intertidal	Net Production 100 % Coverage	Average % Coverage In Intertidal Zone	Net Production At Average % Coverage In Intertidal Zone	Maximum Observed % Coverage	Mean Dry Wt (g/m^2) At Max Observed % Coverage	Net Production At Max Observed % Coverage	P/B (Net Production/Mean Dry Wt)
Fucus	?	35	?	95	264	?	?
Ulva	?	35	?	85	23	?	?
Other	?	30	?				
			?				

Subtidal	Net Production 100 % Coverage	Average % Coverage In Subtidal Zone	Net Production At Average % Coverage In Subtidal Zone	Maximum Observed % Coverage	Mean Dry Wt (g/m^2) At Max Observed % Coverage	Net Production At Max Observed % Coverage	P/B (Net Production/Mean Dry Wt)
Costaria	126	10	13	60	131	90	0.7
Cystoclonium	?	10	?	60	43	?	?
Desmarestia	215	1	2	28	62	43	0.7
Iridaea	38	5	2	80	22	32	1.5
Laminaria	600	10	60	95	77	580	7.5
Microcladia	122	5	6	80	76	102	1.3
Other	125 (d)	59	74				
			157				

? = Not Determined (See Discussion)
a = average of Fucus, Porphyra, and Sargassum
b = average of Microcladia and Neoagardhiella
c = assumes Ulva is average
d = average of Desmarestia, Iridaea, Laminaria, and Microcladia

E. Differences Within and Between Sites

A summary of the net production estimates for each macroalgae species within and between study sites is presented in Table 3.

i. Intertidal vs. Subtidal

At site 1 (Rocky Point) the net production estimates suggest that the intertidal zone is more productive than the subtidal zone per square metre. At Rocky Point the intertidal zone is estimated to have a net production of 178 grams carbon/m^2/year while the subtidal zone is estimated to have a net production of 106 grams carbon/m^2/year. Although, at Rocky Point, most subtidal macroalgae produce more net grams carbon per gram of dry weight per year than intertidal macroalgae, the net production per square metre of the intertidal zone may be higher because of the greater average biomass (dry weight/m^2). However, since the total area of the subtidal zone which supports macroalgae is much larger than the total area of the intertidal zone supporting macroalgae, the subtidal zone at Rocky Point as a whole is probably more productive (in terms of the production of grams carbon/year).

At site 3 (Hardy Bay) the net production estimates suggest that the subtidal zone is more productive than the intertidal zone per square metre and considering total area. At Hardy Bay the net production (grams carbon/m^2/year) of the intertidal zone was unmeasureable, using biomass estimates, while the subtidal zone is estimated to have a net production of 157 grams carbon/m^2/year. Although the average macroalgae biomass (dry weight/m^2) in the intertidal zone seems to be slightly higher than in the subtidal zone, the subtidal macroalgae produce more net grams carbon per gram of dry weight per year. This result offsets any differences in biomass (dry weight/m^2). On a total area basis, the subtidal zone is more productive (in terms of grams carbon/m^2/year) than the intertidal zone because the total area of the subtidal zone supporting macroalgae is much larger than the area of the intertidal zone with macroalgae.

ii. Site 1 (Rocky Point) vs. Site 3 (Hardy Bay)

Net production (grams carbon/m^2/year) estimates suggest that the intertidal zone at Rocky Point is more productive than the intertidal zone at Hardy Bay. However, estimates suggest that subtidal production at Rocky Point and Hardy Bay are very similar. Perhaps differences in environmental conditions affecting net production between the two sites are more prevalent in the intertidal zone than in the subtidal zone. Seasonal fluctuations in net production in the intertidal have been related to variations in air temperature, water temperature, salinity, nutrients, light intensity, photoperiod, and precipitation (Thom, 1981; Pomeroy and Stockner, 1976, Wilkinson, 1980).

On a species for species basis differences in net production can be related to an individual species' growth response to a number of varying environmental factors. For the individual species sampled in this study there is very little data available concerning growth responses to environmental factors. In general, differences in net production for intertidal species may be due to the factors that have been mentioned above. For subtidal species differences in net production may be due to the same factors as for intertidal species with the exception of air temperature and precipitation.

iii. Site 2 (Millstone River Estuary) vs.
Site 1 (Rocky Point) and Site 3 (Hardy Bay)

The net production (grams carbon/m^2/year) estimates suggest that the Millstone River estuary is less productive than either the intertidal or subtidal zones of Rocky Point and Hardy Bay. This suggestion, however, may be inaccurate as the net production of eelgrass present in the estuary was not estimated. Eelgrass has long been known as a major contributor of organic carbon to estuarine food webs. Simenstad and Wissmar (1985) as well as others suggest that estuaries may be more productive, in terms of carbon production, or as productive as marine littoral areas.

F. Comparisons Between Various Marine Plants and Communities

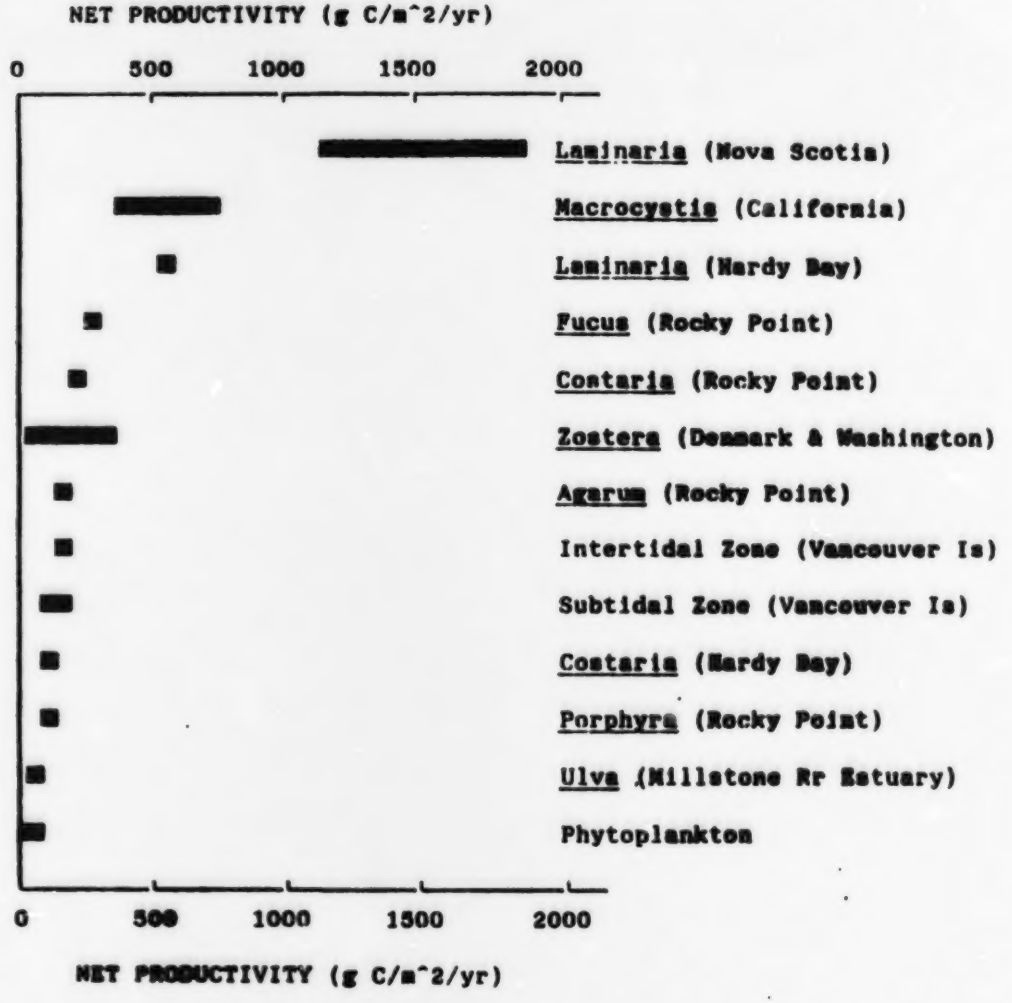
A figure showing comparisons of net productivity of various marine plants and marine plant communities is presented in Figure 4.

Of importance is that even though the total productivity of coastal littoral marine plant communities is small compared to that of phytoplankton in the world's oceans, the productivity of littoral marine plants on an area basis is very large (Carefoot, 1977).

G. Seasonal Variation of Biomass and Its Significance For Inputs To Food Webs

This report suggests that seasonal variations in algal biomass are related to the net productivity (g carbon/m^2/year) of algaes. High seasonal variations in biomass represent high net productivities or high carbon inputs to marine food webs. Carbon inputs to marine food webs include carbon inputs in the form of dissolved organic matter, plant material and particulate detritus. Dissolved organic matter is important in the nutrition of certain invertebrates and other seaweeds. Plant material and particulate detritus provide nutritious food for herbivorous animals. In general, Mann (1972) describes littoral marine plant communities as 'a source of high levels of primary production that helps to create the conditions necessary for the abundant growth of organisms which form the food of young fish'.

Figure 4. Net Productivity of Various Marine Plants and Marine Plant Communities (Data From Mann, 1972; Odum, 1971; Carefoot, 1977; and this study)



Note: Data For Individual Species Assumes 100% Coverage

6.0 References

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